FINANCIAL RISK IN COTTON PRODUCTION

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Abstract

Risk analysis continues to emphasize price and yield variability as the principal components of the decisionmaker's risk environment. This research demonstrates the relative importance of financial risk for a representative cotton farm in Arizona. For highly leveraged operations, financial risk may account for 70 percent of the total risk faced by the producer. Implications for future risk analysis are discussed in light of these findings.

Key words: financial risk, cotton, agricultural finance.

Financial stress in the agricultural production sector represents a topic of major concern for policy analysts, especially those individuals involved with formulating government programs for the 1985 farm legislation. The increased importance of financial stress is demonstrated by higher debt/asset ratios, increasing bankruptcy rates, and an increase in delinquent agricultural loans. Melichar states that agricultural operations with a debt-asset ratio of greater than 40 percent have experienced financial stress in recent years. Statistics of four major cotton producing states demonstrate a slight upward trend in the ratios of total debt to total assets, and real estate debt to real estate assets, Table 1. For example, in Arizona between 1979 and 1982, these ratios increased by less than 10 percent (USDA). However, the ratio involving only nonreal estate debt and assets increased by 33 percent during this same period thereby suggesting that financial stress in these states may be caused more by higher levels of short-term and intermediate financing decisions than by recent land purchases.

Financial risk and financial stress are not synonymous terms. Variability in net cash flows attributed to debt financing (financial risk) may exist without producing financial stress. Nevertheless, financial risk can be an important component of the grower's risk environment although it has not been measured in the literature. The reason for this is that financial variables have not always played a major role in the risk environment of the farm firm. Shepard and Collins found that for the period of 1946-1978, variability in prices and yields (business risk) contributed more to farm failure than did financial considerations. No evidence was found to suggest that increased borrowing leads to a higher rate of bankruptcies. The authors concluded that any decline in liquidity during this period was more than offset by rising land prices and favorable interest rates. However, Barry and Fraser predicted that financial risk would become increasingly important to economic analysis as the agricultural financial markets

TABLE 1. TOTAL, REAL ESTATE, AND NONREAL ESTATE DEBT-TO-ASSET RATIOS FOR THE FOUR LARGEST COTTON PRODUCING STATES BY YEAR, 1979-1982

State	Year 1979	1980	1981	1982
California				
Total	21.4	21.5	20.0	21.0
Real estate	13.4	13.3	12.2	12.7
Nonreal estate	60.2	62.1	63.7	71.0
Texas				
Total	14.1	13.6	13.6	13.3
Real estate	8.4	8.2	8.0	7.3
Nonreal estate	36.8	35.8	39.3	45.1
Mississippi				
Total	18.7	19.1	18.6	22.8
Real estate	12.6	12.7	11.4	13.6
Nonreal estate	37.1	38.8	47.5	56.2
Arizona				
Total	14.0	13.0	13.4	14.2
Real estate	6.0	5.7	6.0	6.1
Nonreal estate	64.7	67.6	70.2	84.5

Source: U.S. Department of Agriculture.

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became less insulated from world financial conditions. Highly leveraged firms with low liquidity would find it difficult to service debts from their cash flow or credit reserves when the financial markets moved against them. This prediction was fulfilled in the early 1980's as land values and product prices declined and highly leveraged farmers experienced financial stress (Melichar).

Economic analysts have reemphasized the importance of financial considerations in modeling the farm firm as a result of recent financial problems in the sector. Hanson and Thompson demonstrated the importance of debt levels in determining cash income for farms of various sizes and enterprise mixes. Boehlje and Eidman formulated a cash flow model which would evaluate the impact of business and financial risks on the agricultural firm. Finally, agricultural producers themselves have indicated the importance of financial management for their firms (Patrick). Interest rates, availability of funds, and the inflation rate were identified as important sources of risk, while timing of investments and the use of credit reserves represented important risk management strategies.

This paper evaluates Barry and Fraser's statement that, *In a more uncertain market environment, it seems reasonable to bring financial choices toward the forefront of risk management.* This research presents a clearer picture of recent components of economic variability, their magnitudes, and trends as a further effort to validate the importance of financial considerations in economic modeling. The model is used to measure the financial, business, and total risks for a representative Arizona cotton farm between 1976-1982. Implications of the results for future risk modeling efforts are also discussed.

ANALYTICAL MODEL

Financial Risk

The total risk (TR) environment of the firm can be decomposed into business risk (BR) and financial risk (FR) (Gabriel and Baker). Business risk is the variability in net cash flows attributed to changes in market and biological factors. Financial risk is the added variability in net cash flows due to debt payments (principal and interest). Following Eidman's formulation, net cash flows before debt payments (NCFB) can be written as:

$$(1)\ \text{NCFB} = \sum_{i=1}^{n} (P_i - C_i)Y_i - F_i - W,$$

where P_i is the price received for the i^{th} product, C_i is the variable cash costs of producing that product, Y_i represents the amount of the i^{th} product produced, F_i is the fixed cash cost that must be paid annually irrespective of the level of production (e.g. property taxes) and W represents the annual family withdrawal for consumption purposes. Net cash flows after debt payments (NCFA) but before taxes can be expressed as:

$$(2)\ \text{NCFA} = \text{NCFB} - P - I,$$

with P and I representing annual principal and interest payments, respectively. After several real or simulated planning periods, the variability in these net cash flow measures can be calculated. Using σ_N to represent the standard deviation in NCFB, the risk components in question can be written as,

$$(3)\ \text{TR} = \frac{\sigma_N}{\text{NCFA}},$$

$$(4)\ \text{BR} = \frac{\sigma_N}{\text{NCFB}},$$

and

$$(5)\ \text{FR} = \frac{\sigma_N}{\text{NCFA}} \cdot \frac{\sigma_N}{\text{NCFB}}.$$

Equation (5) expresses the financial risk measure as a residual value obtained from subtracting business risk from total risk. This formulation assumes that increased levels of debt do not alter business risk (Gabriel and Baker, p. 50). Algebraically, equation (5) can be manipulated to form an expression which shows that FR is a multiplicative function of BR,

$$(6)\ \text{FR} = \frac{\sigma_N}{\text{NCFB}} \cdot \frac{P+I}{\text{NCFA}},$$

indicating that the level of FR is determined by the variability in prices and yield as well as the level of debt financing.[1]

Indications of financial stress are readily obtained from measures of FR using equation (6). Low farm income reduces the cash flow position of the firm, thereby decreasing NCFB and NCFA and increasing FR. Greater uncertainty in cash flows increases σ_N and FR. An increase in leverage can raise principal and interest payments relative to net cash flows which also increases the FR measure. Variations in these factors generate values for FR over a particular time horizon.

Gabriel and Baker used components of this formulation to investigate the tradeoff between business risk and financial risk. For the 1949-76 period, they found that in the aggregate, farm firms respond to declining business risk with increased borrowing (and vice versa). Business and financial risks measures for individual farm firms have received very little empirical attention in the literature, however. The relative magnitude of FR and BR over an unstable time period can be informative for both the risk and policy analyst.

Simulation Model for Arizona Cotton Production

A 1,399-acre farm in central Arizona (Pinal County) was selected as the farming operation which best fit the USDA description of a "typical" Arizona cotton farm (Hatch et al.). Reported annual crop acreages for this firm were obtained from ASCS records for 1976-1982, with cotton, wheat, and alfalfa being the major crops produced. Product prices received by farmers were taken from the Arizona Crop and Livestock Reporting Service annual statistical reports. Hathorn's crop budgets were used to develop the machinery complement to operate this farm in addition to the annual cash production costs. Family living expenses (W) were based on withdrawal in 1975 of $18,000 and adjusted thereafter using the GNP implicit price deflator.

In order to generate an annual measure for the standard deviation of NCFB, net cash flows and σ_N were calculated using random variates for NCFB generated by Monte Carlo simulation techniques (Naylor et al., pp. 68-73). Expected prices and yields were assumed to be a 3-year moving average of previous prices and yields.[2] The standard deviations for both the price and yield variables were calculated as follows:

$$(7)\quad \sigma_{xt} = \frac{\left(\sum_{i=0}^{2} (X_{t-i} - E(X_t))^2\right)^{1/2}}{3},$$

where σ_{xt} is the standard deviation for price or yield (X) in a given year t. Estimates for $E(X_t)$ and σ_{xt} were the parameters used in a normal random number generator to generate 50 observations of price and yield for each of the three crops.[3] These values were combined with annual cash cost data to produce whole-farm net cash flows for the period 1976-1982. Mean NCFB and σ_N calculated from these 50 annual NCFB values and substituted into equation (4) are presented in Table 2. Business risk measures remained remarkably stable over the 7-year period except in 1981 when unexpectedly high cotton prices and yields were responsible for the higher measure of variability in that year. A cotton grower who used no debt financing faced a somewhat constant level of total risk during this time period.

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[1]The algebraic manipulation proceeds as follows from equation (5):

$$FR = \frac{\sigma_N}{NCFB-P-I} - \frac{\sigma_N}{NCFB} = \frac{\sigma_N NCFB - \sigma_N NCFB + \sigma_N P + \sigma_N I}{NCFB(NCFB-P-I)}$$

$$= \frac{\sigma_N}{NCFB} \cdot \frac{P+I}{NCFA}.$$

[2]The use of a moving average to model price expectations has been criticized by Fisher and Tanner. Estimating econometric price expectation models for cotton growers was outside the scope of this research and data set. Informal discussions with cotton growers supported a 3-year moving average as a reasonable expectation for cotton yields.

[3]A one-sample Kolmogorov-Smirnov test was performed on the empirical price and yield distributions of cotton, wheat, and alfalfa. Results for each crop indicated $D^* < D_{.05}$, thereby supporting the use of the normal random number generator.

TABLE 2. CALCULATED MEANS AND STANDARD DEVIATIONS OF NET CASH FLOWS BEFORE DEBT PAYMENTS AND BUSINESS RISK, REPRESENTATIVE CENTRAL ARIZONA COTTON FARM, 1976-1982

Year	NCFB	σ_N	BR
1976	$106,784	52,241	.49
1977	241,237	102,385	.42
1978	124,972	57,948	.46
1979	184,098	102,715	.56
1980	142,535	73,074	.51
1981	188,394	153,226	.81
1982	235,867	116,666	.49

Fixed debt obligations were assumed to represent borrowing for operating costs, machinery and equipment, and land. Cash operating costs for Arizona cotton growers ranged from $400-600 per acre (Hathorn). Electricity to pump water, insecticide costs, and fuel expenses accounted for the majority of these variable costs. Growers commonly use large lines of credit at commercial banks, cotton gins, and Production Credit Associations (PCA) to cover these costs. It was assumed that the grower finances 50 percent of operating costs through the PCA for a period of 9 months. An alternative assumption that the grower finances 90 percent of operating costs through PCA for 9 months was also used in the analysis.

Intermediate debt was computed based on the assumption that the grower refinanced the equivalent of 10 percent of the current value of his machinery and equipment each year at current interest rates. Real estate debt was treated under four alternative assumptions: (1) the grower had clear title to all 1,399 acres, (2) all the land was purchased in 1964 for $350 per acre and financed through the Federal Land Bank with a combination of debt capital at a six percent interest rate and equity capital accounting for 50 percent of the investment, (3) same as

TABLE 3. MEASURES OF TOTAL RISK (TR), BUSINESS RISK (BR), AND FINANCIAL RISK (FR) UNDER ALTERNATIVE FINANCING ASSUMPTIONS FOR A REPRESENTATIVE CENTRAL ARIZONA COTTON FARM, 1976-1982[a]

	Year						
	1976	1977	1978	1979	1980	1981	1982
Clear title							
50% operating costs							
TR	.61	.49	.60	.72	.78	1.18	.67
BR	.49	.42	.46	.56	.51	.81	.49
FR	.12	.07	.14	.16	.27	.37	.18
90% operating costs							
TR	.68	.50	.67	.82	1.03	1.48	.78
BR	.49	.42	.46	.56	.51	.81	.49
FR	.19	.08	.21	.24	.52	.67	.29
50% equity financed land							
50% operating costs							
TR	.77	.52	.73	.82	.88	1.38	.74
BR	.49	.42	.46	.56	.51	.81	.49
FR	.28	.10	.27	.26	.37	.57	.25
90% operating costs							
TR	.89	.54	.84	.96	1.38	1.80	.89
BR	.49	.42	.46	.56	.51	.81	.49
FR	.40	.12	.38	.40	.87	.99	.39
25% equity financed land							
50% operating costs							
TR	.88	.54	.83	.89	1.09	1.49	.79
BR	.49	.42	.46	.56	.51	.81	.49
FR	.39	.12	.37	.33	.58	.68	.30
90% operating costs							
TR	1.04	.57	.96	1.05	1.65	2.00	.96
BR	.49	.42	.46	.56	.51	.81	.49
FR	.55	.15	.50	.49	1.14	1.19	.47
10% equity financed land							
50% operating costs							
TR	.97	.56	.90	.93	1.19	1.58	.82
BR	.49	.42	.46	.56	.51	.81	.49
FR	.48	.14	.44	.37	.68	.77	.33
90% operating costs							
TR	1.17	.59	1.06	1.11	1.88	2.15	1.00
BR	.49	.42	.46	.56	.51	.81	.49
FR	.68	.17	.60	.55	1.37	1.34	.51

[a]Land financing assumes the land was purchased in 1964 at $350/A, with downpayments of 50 percent, 25 percent, or 10 percent. Real estate was financed by a 30-year fixed rate (6 percent) mortgage by the Federal Land Bank. It is assumed that the grower refinances 10 percent of the value of machinery and equipment each year. Either 50 percent or 90 percent of total cash operating costs are financed by a Production Credit Association operating loan for 9 months.

assumption (2) but with 25 percent equity capital, and (4) same as assumption (2) but with 10 percent of the total investment cost in land financed with equity capital. Assumptions (1) and (2) represent a common financial condition among Arizona cotton growers while assumptions (3) and (4) were included to reflect the situation for a higher leveraged, newer farmer. It is recognized that this simulation may be conservative relative to the financial risk situation of young growers getting started in the cotton business.

EMPIRICAL RESULTS

Measures of total risk (TR), business risk (BR), and financial risk (FR) generated by the simulation for the representative Arizona cotton farm are listed in Table 3 and presented graphically in Figure 1. Total risk does vary from year-to-year due to price and yield variability, as well as fluctuations in annual interest rates. TR values are 40 percent higher for the high leverage position because of the cash flow demands created by the debt pay-

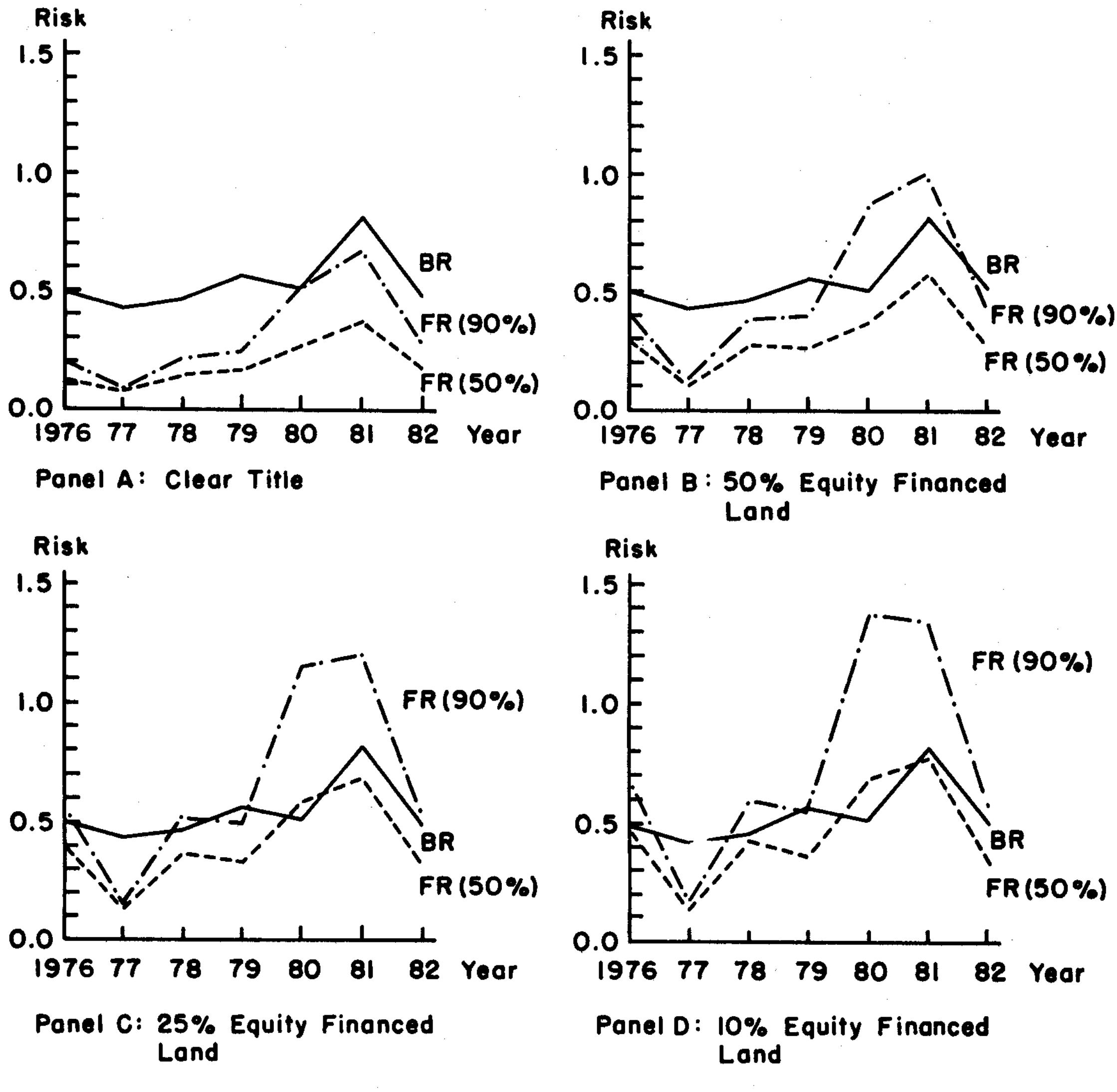

Figure 1. Graphical Measure of Business Risk (BR) and Financial Risk (FR) Under Alternative Real Estate Debt Assumptions (FR (50%) and FR (90%) imply 50 and 90 percent of cash operating cost are financed by the PCA for nine months.).

ment obligations. As expected, higher interest rates for operating capital in 1980 and 1981 increased total risk rather dramatically. These measures validate what analysts have observed using aggregate data (Melichar). Variable, within year interest rates would have produced an even greater rise in total risk.

Panel A of Figure 1 supports the argument that business risk is the major component of the total risk environment for low leveraged producers. Even with 90 percent financing of cash costs, FR accounts for less than 30 percent of TR. However, as interest rates rise to 14-18 percent as they did in 1980-81, FR rapidly gains an equal footing with BR. A comparison of Panel A with the other panels clearly illustrates why there are many low leveraged agricultural producers who can withstand variability in the financial markets better than variability in the product markets.

Panels B through D provide support for Barry and Fraser's position of the need for increased emphasis on financial considerations in risk management. Financial risk at the 90 percent financing level is a significant source of risk under the assumptions of Panel B. But during the 1978-1982 period, FR becomes the principal source of risk for the Arizona cotton grower given the real estate debt assumptions of Panels C and D. Actually, FR may be twice that of BR for relatively highly leveraged growers (Panel D). Even financial risk at the 50 percent financing level is comparable to BR in 1980 and 1981 for the last two scenarios.

Several immediate implications can be drawn from these results. First, these findings illustrate that in certain years business risk for many producers can account for less than 50 percent of the risk faced by the decisionmaker. Emphasis on price and yield variability should be shared with uncertainty in the financial sector. Secondly, young farmers who buy land will face financial risk levels which surpass those of Panel D. Government actions to reduce and stabilize the sources of financial risk, principally interest rates, could encourage more young people to enter and establish themselves in the agricultural production sector. These results also support the claims of policy analysts who have emphasized the cash flow problems in agriculture (Tweeten; Gardner). Variability in prices, yields, and interest rates make cash flow considerations an important factor in determining the economic health of the agricultural sector.

IMPLICATIONS FOR RISK ANALYSIS

Financial considerations are critical for the success of farm firm and aggregate level modeling efforts. Success implies the ability to accurately predict optimum production and marketing strategies and generate information needed by the agricultural clientele group in making decisions. The results presented in this paper illustrate the relative importance of financial risk in sucessfully describing the uncertain economic environment faced by the grower. It also has been shown, in a risk framework, why low leveraged growers have been able to withstand the financial pressures of the early 1980s while highly leveraged operations have experienced large debt carry overs, refinancing, and foreclosure.

Research efforts to predict optimal or preferred farm plans under conditions of uncertainty generally have produced a predicted plan which is less conservative than the actual or representative farm plan (Lin et al.; Held and Zink). Maximization of profit, mathematical programming, Bernoullian utility, and lexicographic utility models typically predict more risky behavior than is actually observed. Producers tend to operate within an efficient set and at mean and variance levels which are below optimal levels. Sanint and Barry showed, using a multiperiod quadratic programming model, that the incorporation of credit risk into a model raised overall portfolio risk. This modification of the risk-efficient set produced an optimal solution with lower variance and lower expected value than would a solution using only business risk factors. The implication is that the incorporation of financial risk into modeling efforts may improve the reliability and accuracy of the predictions. Financial risk measures for cotton production presented in this paper lend significant support to the argument for including financial variables in risk analysis.

CONCLUDING REMARKS

Gabriel and Baker's formulation of risk components represents a useful tool for risk analysis. However, a more robust measure of financial risk is needed. The existing formulation does not model negative cash flows without violating the intuitive understanding of the scale and sign of risk measures. A coefficient of variation-type measure may not be the appropriate formulation for these future efforts. A procedure which analyzes the entire distribution of simulated cash flows against a benchmark distribution may be a possible alternative.

Any new formulation of the components of total risk should include a broader treatment of the economic environment than was treated in this research. Input variability, both in prices and quantities, represents a valid source of risk. Pest control in cotton production is an ideal example of an agricultural input activity with as much inherent variability as output prices and yields. In addition, output quantities are actually a function of the grower's input decisions thereby increasing the complexity of the new formulation with the use of conditional probabilities. Also, taxation represents a factor which influences the total risk environment. After-tax measures of total, business, and financial risks surely would vary from the results in this paper.

Finally, policy analysts should encourage the measurement of these risk indicators for alternative "typical" farm types as defined by the USDA. Farm size, product mix, type of agriculture (non-irrigated vs. irrigated), and leverage position are among the key variables which determine the producer's risk position and decisionmaking attitudes. Response to and impact of government programs (e.g. Payment in Kind) and economic events (e.g. higher interest rates) may be more accurately predicted for the farm sector if these risk relationships by farm type were accurately measured.

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